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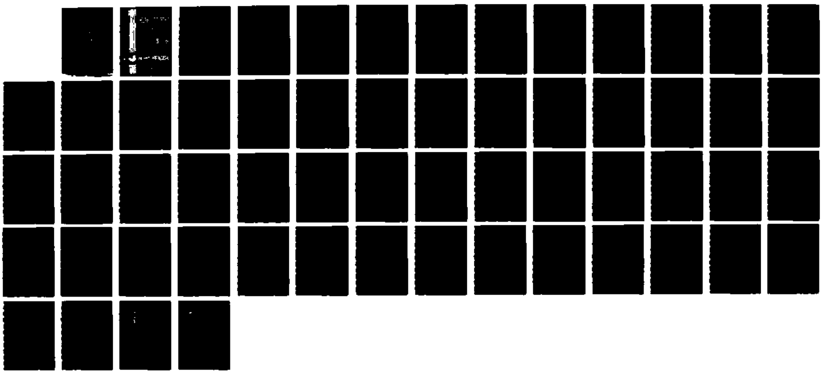

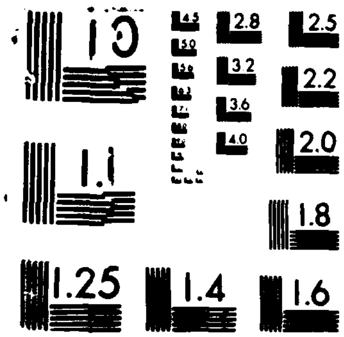
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ESL-TR-86-25

Effectiveness of Commercially Available Home Water Purification Systems for Removing Organic Contaminants

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SEPTEMBER 1986

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The objective of this study was to determine the efficiency of several home water filters in removing organic chemicals that have contaminated groundwaters on or near Air Force installations. Several commercially available carbon filters provide high removal efficiencies for chemicals such as trichloroethylene, benzene, 1,1,1-trichloroethane, ethyl benzene, and vinyl chloride. The results of independent and manufacturer tests are provided to assist Air Force and DOD engineers in assessing the home water treatment alternative for their unique water supply situations. (Keywords)

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PREFACE

This report was prepared by the Dynamac Corporation, Rockville, Maryland 20852, under contract F08635-85-C-0057 for the Air Force Engineering and Services Center, Engineering and Services Laboratory (AFESC/RDVW), Tyndall AFB FL 32403.

This report summarizes a comprehensive literature review that was conducted between January and May of 1986. The HQ AFESC/RDVW program manager was Mr Doug Downey, and the Dynamac project officer was Mr Rick Cole.

This report has been reviewed by the Public Affairs (PA) Office and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nationals.

This technical report has been reviewed and is approved for publication.

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SECTION I

INTRODUCTION

A. OBJECTIVE

This study was conducted to determine the efficiency of home water filters in removing organic chemicals that may be detected in drinking water contaminated with leachate from a hazardous waste site. Contaminants commonly found at these sites include: trichloroethylene, 1,1,1-trichloroethane, vinyl chloride, benzene, and ethyl benzene.

The results of the evaluation process are the basis of this manual which can be used as an aid in selecting the more efficient units. Included information provides the operator with the background to properly maintain the unit, ensuring that the filter will operate at its maximum removal efficiency.

B. BACKGROUND

Point-of-use water treatment has increased as water sources have become more contaminated with low-level organic contaminants and as the public has become more concerned about the quality of its drinking water. Centralized water treatment is effective in processing large amounts of drinking water to relatively safe levels, but the growing number of known contaminant spills may render centralized treatment ineffective in removing pollutants to the desired safe levels. These desired levels are within the low parts per billion range; most are less than 10 ppb. Also at risk are private wells bordering Air Force installations with contaminated spill areas. These wells receive minimal, if any,

water treatment. Table 1 lists the EPA proposed maximum contaminant levels for eight volatile organic chemicals found in drinking water.

Activated carbon is the most widely used point-of-use system for home treatment of water. Other technologies available are: (1) reverse osmosis, (2) distillation, (3) ozonation, and (4) ultraviolet. Except when suspended solids or high inorganics are a problem, activated carbon is the choice of treatment. Carbon units are ineffective in removing suspended solids and dissolved inorganics. The carbon units are normally the easiest to install and maintain, operating costs are limited to replacement filter costs, and their performance in removing organic pollutants is excellent. The measure of performance is based on those top-of-the-line units, which are not necessarily the most expensive. The performance of an individual unit depends on a combination of factors such as the: (1) unit design, (2) type and amount of activated carbon, and (3) contact time - the hold-up time in which the water is in contact with the carbon. Most units utilize granular activated carbon in their designs; other forms include a pressed carbon block, and powdered carbon. Of the three, powdered carbon is the least effective, due to channeling of the water through the filter. As a result, the contact time with the carbon is lessened. An improper filter design can also cause channeling regardless of the carbon form. Of the units listed in Table 2, only the Amway filter has the pressed carbon block as the filter media.

TABLE 1. PROPOSED EPA MAXIMUM CONTAMINANT LEVELS

COMPOUND	mg/l
Trichloroethylene	0.005
Carbon Tetrachloride	0.005
Vinyl Chloride	0.001
1,2 - Dichloroethane	0.005
Benzene	0.005
1,1 - Dichloroethane	0.007
1,1,1 - Trichloroethane	0.200
p - Dichlorobenzene	0.750

TABLE 2. PERFORMANCE DATA FOR SELECTED UNITS.

Unit	Rated Capacity (gal)	THM[1]	Average NPTOC[2]	Percent Removal Halogenated Organics
Continental, Model 350	720	99	87	99
Everpure QC4-THM	1,000	99	55	99
Aqualux CB-4	2,000	98	23	99
Culligan, Model SG-2	4,000	89	28	99
Amway	500	99	-	98

[1] Trihalomethane Reduction

[2] Nonpurgeable Total Organic Carbon Reduction

Another important difference in assessing the performance of various filters, is the rated lifetime capacity, expressed in gallons of water filtered. This number is assigned by the manufacturer. Another term used to express filtering capacity is rated gallonage. The capacities of these filters differ according to the manufacturer; ranges are from 500 to 4,000 gallons. Most manufacturers do not recommend using their filters beyond the rated filtering capacity. Once the capacity is surpassed there exists the potential for unloading. When unloading occurs, contaminants are released from the carbon filter, often in concentrations higher than those in the influent to the filter. Such dosages would present major health risks. Thus, in selecting a filter, patterns of higher water usage may warrant choosing a unit with a higher filtering capacity.

A major concern in using activated carbon filters is the possible health effects from the resulting bacteriological increase in the effluent filter water. This has prompted many manufacturers to include silver as a bacterial inhibitor. Units which include silver are labeled bacteriostatic. Standard plate counts on silverized versus nonsilverized units indicate there is no statistical difference. Other data suggest silver may be effective at lower pH levels.

Theoretically, the carbon filter, by removing organic contaminants, provides the bacteria with an excellent growth medium accompanied by a constant supply of nutrients. Since the health significance of an increase in microbiological activity has yet to be quantified, there is considerable debate on the possible effects. A major portion of the available literature

on home water treatment addresses this potential problem. Adverse health effects from the use of activated carbon units have not been documented. Much of the data from bacteriological studies point to an increase in the microbial activity after periods of stagnation, i.e., overnight. This same increase is seen in systems without carbon filters, caused by airborne bacteria colonizing the end of the faucet. Flushing water for about 30 seconds to 1 minute after periods of stagnation would be an effective precautionary measure. Standard plate counts on samples taken after flushing are considerably lower than on those samples taken as the first water out. For the present, increased drinking water quality, from using activated carbon filters outweighs possible side effects. With proper maintenance and use, home water treatment units can be used safely and effectively to remove the hazardous organic chemicals present in contaminated drinking water.

C. SCOPE

Data from various scientific studies on the performance of home water filtration units were evaluated to determine the best unit design and the efficiency of that unit in removing halogenated organic contaminants. The combination of initial cost, low maintenance, ease of installation, and contaminant removal performance proved the activated carbon filter to be the best choice.

The data in Table 2 are a good indication of the expected performance for a well-designed carbon filter. This report provides background information on the different types of home

purification systems, but the main emphasis is on activated carbon filters and their use. Use of this manual will help determine the appropriate size and type of carbon filter for a given application.

SECTION II

LITERATURE SYNOPSES

This section contains summaries of selected articles from the literature review. These were chosen as the more pertinent material, presenting the results of various studies and performance data on filters differing in type, design, and manufacturer.

A. STUDIES ON HOME WATER TREATMENT SYSTEMS (Bell, Frank A., et al.)

This report presents results of a study on home water treatment systems conducted by Gulf South Research Institute (GSRI) under a grant from the U.S. Environmental Protection Agency.

Statistical data for over 30 units, employing activated carbon as the absorbant, is furnished. The study was conducted in a series of three phases. The first phase consisted of testing a few units under an accelerated schedule, to establish testing procedures and protocol.

Phase two evaluated additional units according to the test protocol developed in phase one, for trihalomethane (THM) and nonpurgeable total organic carbon (NPTOC) reductions. The filters were tested with New Orleans tap water in which the average THM concentration was approximately 200 µg/L. The trihalomethane group includes chloroform, bromoform, dichlorobromethane, and dibromochloromethane. These compounds are formed from the reaction of chlorine with humic acid and other organics

present in drinking water. The average THM reduction was 61 percent with a range from 6-99 percent.

The third phase consisted of a groundwater and surface water study in which removal efficiencies for specific organics are given. Ten of the more efficient units from Phase 1 were selected for further study. The source groundwater chosen was relatively free of contamination to facilitate spiking. The units were challenged with 20 µg/L carbon tetrachloride, 50 µg/L trichloroethylene, 50 µg/L tetrachloroethylene, and 50 µg/L 1,1,1-trichloroethane. Corresponding removal efficiencies ranged from 40-99 percent.

The surface water study was similar in design and used the same 10 units. Each was challenged with 10 µg/L p-dichlorobenzene,10 µg/L hexachlorobenzene, and 50 µg/L chlordane. Again removal efficiencies varied among the filters from a low of 20 to a high of 99 percent removal. The data in Tables 3 and 4 summarize the performance of the most efficient filters.

Throughout both studies, bacteriological activity in the carbon filters was measured by the standard plate count. The heterotrophic bacteria count was considered moderate and variable within the filters when compared with samples from a control loop without a filter. The health risk of such exposure is still undetermined. Because the highest levels of bacteria were found in the water after a period of stagnation, a common practice of flushing for 30 seconds to 1 minute after quiescent periods should be established.

TABLE 3. REMOVAL RATES FOR MOST EFFICIENT UNITS IN GSRI STUDY[3]

Unit	Percent THM[1]	Percent NPTOC[2]	Halogenated Organics Influent (µg/L)	Halogenated Organics Effluent (µg/L)	Halogenated Organics Percent Removal
Line bypass					
Continental, Model 350	99	87	134	1.35	99
Everpure QC4-THM	99	55	158	1.33	99
Aqualux CB-4	98	23	132	1.45	99
Culligan, Model SG-2	89	28	144	1.60	99
Aquacell	86	23	132	1.63	97
Seagull IV	81	41	158	1.36	97
Faucet-mounted					
Hurley Town & Country	69	31	143	1.47	97

1 Trihalomethane reduction.

2 Nonpurgeable Total Organic Carbon reduction.

3 Note that rates are expressed as an average over the lifetime capacity for each filter.

TABLE 4. RANGE OF PERCENTAGE REDUCTION FOR SPECIFIC HALOGENATED ORGANICS

Unit	Range of Average Percentage Reduction (Beginning-Ending)		
	1,1,1-Trichloroethane	Carbon Tetrachloride	Trichloroethylene
Line bypass			
Aquacell	99-93	99-95	99-98
Aqualux CB-2	99-99	98-96	99-99
Continental, Model 350	99-99	99-99	99-99
Culligan, Model SG-2	99-98	99-98	99-99
Everpure QC4-THM	99-99	95-99	99-99
Seagull IV	98-95	98-97	98-97
Faucet-mounted			
Hurley Town and Country	99-93	97-94	99-98

TABLE 4. RANGE OF PERCENTAGE REDUCTION FOR SPECIFIC HALOGENATED ORGANICS (CONCLUDED)

	Range of Average Percentage Reduction (Beginning-Ending)			
	Tetrachloroethylene	p-Dichlorobenzene	Hexachlorobenzene	Chlordane
Line bypass				
Aquacell	99-97	99-96	99-80	99-89
Aqualux CB-2	99-99	99-90	99-54	99-89
Continental, Model 350	99-99	95-95	85-95	99-99
Culligan, Model SG-2	99-99	77-89	99-45	95-83
Everpure QC4-THM	99-99	99-99	99-99	99-99
Seagull IV	98-97	99-99	99-99	99-98
Faucet-mounted				
Hurley Town and Country	99-99	99-92	99-50	99-79

B. DEVELOPMENT OF BASIC DATA AND KNOWLEDGE REGARDING ORGANIC REMOVAL CAPABILITIES OF COMMERCIALLY AVAILABLE HOME WATER TREATMENT UNITS UTILIZING ACTIVATED CARBON: PHASE 1, PRELIMINARY REPORT"
(Gulf South Research Institute Report to EPA)

The principal purpose of Phase 1 was to develop data and information on a limited number of treatment units to provide guidance on the test procedures for use in larger-scale testing to be conducted in Phase 2.

The complete results of the EPA report are presented in the paper entitled "Studies on Home Water Treatment Systems," which is included in the synopsis list.

Of primary interest is the test protocol development. The seven units were evaluated on their capacity for removing nonpurgeable total organic carbon (NPTOC), trihalomethanes (THM), free and total chlorine, nonpurgeable total organic halide, standard plate count, and endotoxin level. Analyses were run at 0, 25, 50, 75, and 100 percent of the filters' lifetime according to the manufacturer. Subsequent tests in the later phases surpassed manufacturers' lifetime claims. Analyses were either standard methods or EPA-approved procedures. For the THM/NPTOC and SPC/endotoxin analyses, the residual chlorine in the samples had to be neutralized. Sodium sulfite was added to the samples for THM/NPTOC. The silver and chlorine in samples collected for SPC/endotoxin analysis were inactivated with the addition of a sodium thiosulfate/sodium thioglycolate mixture. Samples were stored at 4°C until analyzed.

The challenge water flow through each unit was divided into an 8-hour stagnation period and a 16-hour cycling period. During

the cycling period, flow time was initiated by a timer cam-control system. Flow through the test units was set at 6 minutes per hour for the 16-hour period, or 96 minutes per day. This pattern of cycling was set to simulate in-home use. Bacteriological samples were taken on both influent and effluent waters immediately after the stagnation period each day. In addition, samples were collected after the daily test cycle had begun. These were taken over the life (rated gallonage) of the unit.

Chemical samples were collected 6 hours after the start of the daily cycle. Water was run to waste for 1 minute before collecting samples to alleviate collection of a sample having an extended contact time with the activated carbon. Filters were run until manufacturer's rated gallonage had been processed or until the unit plugged prematurely. Once the run was terminated the filter was held at line pressure and a bacteriological sample was taken 5 days later.

C. THE AMWAY WATER TREATMENT SYSTEM, (Amway Corporation)

The Amway Corporation has introduced a home water filter of its own design. The filter differs from the majority of carbon filters in that it contains a pressed carbon block instead of the normal granular activated carbon. It is being promoted as a more efficient design for reducing contaminant concentrations.

Supporting data is presented for over 100 soluble and insoluble organic EPA priority pollutants in which the effluent contaminant concentration from the filter is 1.5 ppb or less. Removal percentages are greater than 97.8 at the filter's rated capacity (500 gals). Trihalomethane removal exceeded

95 per cent. Testing was conducted to 750 gallons, 50 per cent beyond filter life.

Further claims promote the removal of precipitated heavy metals, asbestos, sediment, dirt, scale and Giardia lamblia cysts. Analytical testing procedures and supporting data are presented for each claim.

The Amway Corporation is claiming that a filter will last the average family 1 year. The filter is rated to 500 gallons; therefore, the average daily water use would be less than 2 gallons. This figure appears low. Other estimates have put the daily drinking water consumption rate for a family of four at 3 to 5 gallons per day. This would require filter changes two to three times per year.

The data presented from the Amway study were obtained from testing the filters to 50 per cent beyond their rated capacity of 500 gallons. The data clearly prove that carbon filters can be used effectively for removing pollutants. Other studies, using a longer test life of 2000-3000 gallons, have identified carbon filters which have excellent performance through the first half of the study; then removal performance drops, often dramatically. Because the performance of the Amway filters beyond 750 gallons is not known, any comparisons between various carbon filters should be made over the same test range.

A potential problem when testing for insoluble organic pollutants is their very low solubility, almost negligible, in water. However, given a large surface area and an extended

contact time, these relatively insoluble contaminants are often present in low concentrations. Within the laboratory it becomes exceedingly difficult to solubilize these compounds for testing. In the Amway study, the contaminants were dissolved in a minimum of a methanol/acetone solvent. The presence of this solvent probably had no contributing effect toward increased filter performance. One should realize that this solvent mixture is not normally present in drinking water.

TABLE 5. AMWAY DATA FOR WATER-SOLUBLE ORGANICS

Compound	Detection Limit (ppb)	Measured Average Influent (ppb)	Effluent @ 550 Gal. (ppb)	Effluent @ 750 Gal. (ppb)	Calculated Total (mg) Loading
Acenaphthene	0.1	52	<DL*	<DL	156.6
Chlorobenzene	0.1	8	<DL	<DL	22.9
1,2,4-Trichlorobenzene	0.1	81	<DL	<DL	245.7
1,2-Dichloroethane	0.1	11	<DL	<DL	33.5
1,1,1-Trichloroethane[1]	0.1	7	<DL	<DL	20.1
1,1,2,2-Tetrachloroethane[2]	0.1	7	<DL	<DL	21.7
Bis (2-Chloroethyl) ether	0.3	19	<DL	<DL	57.3
2-Chloronaphthalene	0.1	84	<DL	<DL	253.2
2,4,5-Trichlorophenol	0.1	96	<DL	<DL	290.8
para-Chloro-meta-cresol	0.1	18	<DL	<DL	53.3
2-Chlorophenol	0.1	29	<DL	<DL	89.1
1,2-Dichlorobenzene	0.1	67	<DL	<DL	202.1
1,3-Dichlorobenzene	0.1	25	<DL	<DL	74.7
1,4-Dichlorobenzene	0.1	78	<DL	<DL	235.9
1,1-Dichloroethylene	0.1	1	<DL	<DL	2.8
1,2-trans-Dichloro-ethylene	0.1	11	<DL	<DL	34.1
2,4-Dichlorophenol	0.1	49	<DL	<DL	147.0
1,2-Dichloropropane	0.1	14	<DL	<DL	41.0

[1] 1,1,1-trichloroethane and 1,1,2-trichloroethane: values are the sum of the two compounds due to chromatographic overlap.

[2] 1,1,2,2-tetrachloroethane and tetrachloroethylene: values are the sum of the two compounds due to chromatographic overlap.

* Below detection limit

TABLE 5. AMWAY DATA FOR WATER-SOLUBLE ORGANICS(CONTINUED)

Compound	Detection Limit (ppb)	Measured Average Influent (ppb)	Effluent @ 550 Gal. (ppb)	Effluent @ 750 Gal. (ppb)	Calculated Total (mg) Loading
1,3-Dichloropropylene[3]	0.1	168	<DL	<DL	508.4
2,4-Dimethylphenol	0.1	5	<DL	<DL	16.0
2,4-Dinitrotoluene	0.1	93	<DL	<DL	280.0
2,6-Dinitrotoluene	1.0	111	<DL	<DL	334.0
Fluoranthene	0.1	34	<DL	<DL	102.05
4-Chlorophenyl phenyl ether	0.2	56	<DL	<DL	170.8
4-Bromophenyl phenyl ether	0.1	33	<DL	<DL	100.3
Bis (2-Chloro-isopropyl) ether	0.2	105	<DL	<DL	318.9
Bis (2-Chloro-ethoxyl) methane	0.3	91	<DL	<DL	274.7
Bromoform	0.1	6	<DL	<DL	18.5
Trichloro-fluoromethane	0.1	3	<DL	<DL	8.1
Dichlorobromomethane	0.1	31	<DL	<DL	93.4
Chlorodibromomethane[3]	0.1	168	<DL	<DL	508.4
Hexachlorobutadiene	0.1	20	<DL	<DL	61.0
Hexachlorocyclo-pentadiene	0.1	43	<DL	<DL	131.4
Isophorone	0.1	104	<DL	<DL	314.1
Naphthalene	0.1	55	<DL	<DL	167.[illegible]
Nitrobenzene	0.1	111	<DL	<DL	334.1
2-Nitrophenol	0.1	78	<DL	<DL	236.0

[3] 1,3-dichloropropylene and chlorodibromomethane: values are the sum of the two compounds due to chromatographic overlap.

TABLE 5. AMWAY DATA FOR WATER-SOLUBLE ORGANICS(CONTINUED)

Compound	Detection Limit (ppb)	Measured Average Influent (ppb)	Effluent @ 550 Gal. (ppb)	Effluent @ 750 Gal. (ppb)	Calculated Total (mg) Loading
4-Nitrophenol	0.1	127	<DL	<DL	383.4
2,4-Dinitrophenol	0.2	32	<DL	<DL	96.6
4,6-Dinitro-o-cresol	0.2	77	<DL	<DL	233.6
n-Nitrosodiphenylamine	1.0	72	<DL	<DL	218.6
Pentachlorophenol	0.1	45	<DL	<DL	135.5
Phenol	0.1	31	<DL	<DL	94.1
Butyl benzyl phthalate	0.2	86	<DL	<DL	260.7
Di-n-octyl phthalate	0.1	12	<DL	<DL	37.4
Di-n-butyl phthalate	0.2	51	1.3	1.5	155.0
Diethyl phthalate	1.0	65	<DL	<DL	195.7
Dimethyl phthalate	0.5	90	<DL	<DL	270.8
Acenaphthylene	0.2	58	<DL	<DL	174.1
Anthracene	0.1	8	<DL	<DL	23.4
Fluorene	0.1	50	<DL	<DL	152.0
Phenanthrene	0.3	18	<DL	<DL	55.7
Pyrene	0.1	20	<DL	<DL	59.3
Tetrachloro-ethylene*	0.1	7	<DL	<DL	21.7
Trichloroethylene	0.1	34	<DL	<DL	102.1
Dieldrin	0.2	144	<DL	<DL	436.3
Endrin	0.2	216	<DL	<DL	652.0
Heptachlor	0.1	85	<DL	<DL	256.1
Heptachlor epoxide	0.1	4	<DL	<DL	13.1
gamma-BHC (lindane)	0.1	149	<DL	<DL	451.7
Hexachloroethane	0.1	4	<DL	<DL	13.[illegible]

TABLE 5. AMWAY DATA FOR WATER-SOLUBLE ORGANICS(CONCLUDED)

Compound	Detection Limit (ppb)	Measured Average Influent (ppb)	Effluent @ 550 Gal. (ppb)	Effluent @ 750 Gal. (ppb)	Calculated Total (mg) Loading
1,1-Dichloroethane	0.1	13	<DL	<DL	40.1
1,1,2-Trichloroethane[1]	0.1	7	<DL	<DL	20.1
Chloroform	0.1	30	<DL	0.2	91.1
4,4'-DDD	0.2	101	<DL	<DL	306.9

TABLE 6. AMWAY DATA FOR WATER-INSOLUBLE ORGANICS

Compound	Detection Limit (ppb)	Calculated Average Influent (ppb)	Effluent @ 550 Gal. (ppb)	Effluent @ 750 Gal. (ppb)	Calculated Total (mg) Loading
Acrolein	0.1	121	<DL*	<DL	336
Benzene	0.1	95	<DL	<DL	264
Carbon tetrachloride	0.1	229	<DL	<DL	636
Bis (chloromethyl) ether	0.1	19	<DL	<DL	52
2-chloroethyl vinyl ether (mixed)	0.1	155	<DL	<DL	431
1,2-diphenyl-hydrazine	0.1	14	<DL	<DL	38
Ethylbenzene	0.1	36	<DL	<DL	433
Dichlorodi-fluoromethane	0.1	36	<DL	<DL	100
n-Nitrosodi-n-propylamine	0.1	74	<DL	<DL	206
n-Nitrosodi-methylamine	0.1	145	<DL	<DL	403
1,2-Benzanthracene	0.1	18	<DL	<DL	50
3,4-Benzopyrene	0.1	94	<DL	<DL	260
3,4-Benzo-fluoranthene	0.1	71	<DL	<DL	197
11,12-Benzo-fluoranthene	0.1	70	<DL	<DL	195
Chrysene	0.1	72	<DL	<DL	201
1,12-Benzo-perylene	0.1	72	<DL	<DL	200
1,2:5,6-Dibenzo-anthracene	0.1	91	<DL	<DL	252
Toluene	0.1	145	<DL	<DL	404

* Below Detection Limit

TABLE 6. AMWAY DATA FOR WATER-INSOLUBLE ORGANICS (CONCLUDED)

Compound	Detection Limit (ppb)	Calculated Average Influent (ppb)	Effluent @ 550 Gal. (ppb)	Effluent @ 750 Gal. (ppb)	Calculated Total (mg) Loading
Aldrin	0.1	68	<DL	<DL	190
Chlordane (technical mixture and metabolites)	0.1	15	<DL	<DL	43
4,4'-DDT	0.1	78	<DL	<DL	218
4,4'-DDE	0.1	160	<DL	<DL	445
alpha-Endosulfan	0.1	20	<DL	<DL	55
beta-Endosulfan	0.1	20	<DL	<DL	57
Endosulfan sulfate	0.1	29	<DL	<DL	80
alpha-BHC	0.1	38	<DL	<DL	106
beta-BHC	0.1	12	<DL	<DL	34
delta-BHC	0.1	20	<DL	<DL	56
PCB-1016 (Aroclor 1016)	0.1	64	<DL	<DL	179
PCB-1221 (Aroclor 1221)	0.1	51	<DL	<DL	143
PCB-1232 (Aroclor 1232)	0.1	27	<DL	<DL	75
PCB-1248 (Aroclor 1248)	0.1	79	<DL	<DL	220
PCB-1254 (Aroclor 1254)	0.1	65	<DL	<DL	181
PCB-1260 (Aroclor 1260)	0.1	119	<DL	<DL	330
Toxaphene	0.1	73	<DL	<DL	203
3,3'-Dichlorobenzidine	0.1	54	<DL	<DL	150
Chloroform	0.1	50	5.6	4.3	139

D. UPDATE ON HOME TREATMENT DEVICES, (AWWA Research Foundation, Water Quality Research News)

This article summarizes the work done at Gulf South Research Institute through November 1980. The test plan and type of filtration devices are identified. The test program simulated home use conditions and adhered to manufacturers' instructions for installation and use. In fact, the filters were tested beyond the manufacturers' lifetime claims.

Five distinct measurements were conducted on the effluent water from each filter: trihalomethane (THM) reduction, non-purgeable total organic carbon (NPTOC), bacterial numbers by standard plate count (SPC), endotoxin level, and silver concentration. Silver concentration was determined, since several filters claimed to be bacteriostatic, employing silver to inhibit bacterial growth.

The filters were categorized into five general groups.

1. Line bypass:

   Connect to water line under the sink, for treatment. The treated water is routed to a separate faucet.

2. Stationary units:

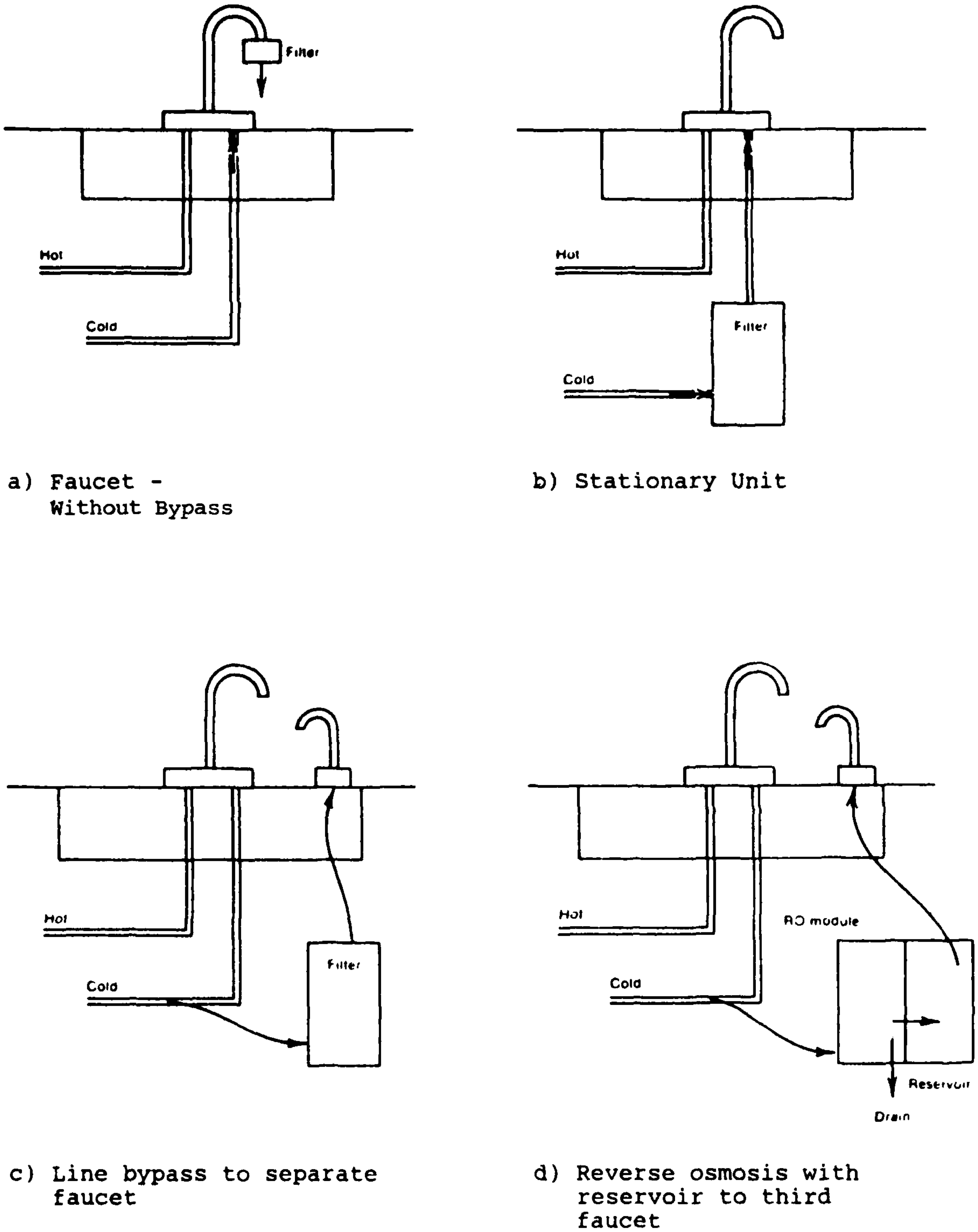
   Connect to water line under sink; however, all water is treated. No separate faucet.

3. Faucet bypass:

   Attach to the faucet, allowing water to flow untreated, or switch the flow through the unit for treatment.

4. Faucet, without bypass:

   All water is treated through unit on faucet.



a) Faucet - Without Bypass

b) Stationary Unit

c) Line bypass to separate faucet

d) Reverse osmosis with reservoir to third faucet

Figure 1. Basic Applications of Point-of-Use Units.
A - C are Activated Carbon Units.

5. Portable pour-through:

Unit is not connected to either faucet or water line. Water is treated as it is poured in unit. The following table summarizes the performance of the units as a group for removing THM and NPTOC.

TABLE 7. PERCENT REDUCTION EFFICIENCIES

Unit	THM Range	THM Average	NPTOC Range	NPTOC Average
Line Bypass	23-99	61	0-87	23
Stationary	15-46	21	7-12	9
Faucet Bypass	6-69	41	6-31	12
Faucet Nonbypass	6	6	2	2
Portable Pour-through	19-40	21	6-14	-

Factors governing THM and NPTOC removal are: (1) quantity and type of carbon, (2) contact time, and (3) design features.

The silver gave no statistical indications of inhibiting bacterial growth. No significant reduction occurred in the growth patterns of the 13 silvered units when compared with the SPC numbers of 17 nonsilvered units. None of the bacteria were identified to be in the coliform group. Moreover, the endotoxin maximums of the test units were comparable to the maximum levels of 27 public water supplies. Endotoxins are released by bacteria upon their death, and are used as a measure of bacteriological activity.

E. WATER TREATMENT HANDBOOK, A HOMEOWNERS GUIDE TO SAFER DRINKING WATER,(Ebbert, Suzanne, et al.)

This book, published by the Rodale Press Product Testing Department and written for the layman, provides a good introduction to the problems associated with water quality and treatment. The

various treatment systems are explained in detail in nontechnical terms.

Of particular interest is the section in which several reverse osmosis systems are tested for removal performance. The data presented in the report may be questioned as to the technical and scientific validity due to its presence in a consumers' magazine; consequently, the results are used as a guide to selecting the more efficient systems for further study and are not to be interpreted as absolute performance ratings.

Reverse Osmosis (RO) systems, when combined with a carbon pre- or postfilter, are an efficient means of removing organics, as well as suspended solids and inorganics. Additionally the membrane may provide an impenetrable barrier to the bacteria. Five RO systems were tested in this report--three of which gave excellent results. The units were challenged with river water from the Delaware and Schuylkill Rivers. The compounds and average concentrations are listed in Table 8. The summary performance of the top three RO units is included in Table 9. The carbon filter is included for cost comparison analysis between different treatment technologies.

The two analytical tests run were total organic halide (TOX) and EPA 601, Purgeable Halocarbons.

TABLE 8. AVERAGE CONCENTRATION OF CONTAMINANTS FOUND IN THE CHALLENGE RIVER WATER

ORGANICS µg/L		INORGANICS mg/L		BACTERIA AND pH	
Chloroform	52.65	Free Chlorine	.0675	pH	7.325
Bromodichloro-methane	14.125	Total Chlorine	.1975	Bacteria Count	42.5 (number per mL)
Dibromodichloro-methane	2.24	Total Hardness	5.666 grains/gallon		
Methylene	11.005	Sodium	17.8		
Chloride 1,2-Dichloropro-pane	.325	Chloride	35.175		
		Fluoride	.88		
CIS 1,3-Dichlo-ropropene	.875	Nitrate	1.775		
		Aluminum	.0905		
Tetrachloro-ethene	.5776	Total Dissolved Solids	138.75		
Total Organic Halides	994.0				

TABLE 9. PERFORMANCE DATA FOR REVERSE OSMOSIS UNITS TESTED BY RODALE PRESS PRODUCT TESTING DIVISION

Unit	Description	Production Rates	Removal Rates							Cost Factors ($)[1]	
			Organics (% Removed)		Inorganics (% Removed)						
		Product Water Capacity (Gal/Day)	Total Organic Halide	Total Trihalo-methane	Total Cl	TDS	Na	F	NO_3	Estim. Cost/Gallon	Approx. Cost of Unit
REVERSE OSMOSIS SYSTEMS											
Coast Filtration WS/RO-5	6 sq ft cellulose-triacetate membrane, .5 sq. ft 1 micron sediment filter, 16 oz block carbon postfilter.	3.2	>92	>99	>91	96	93	>89	89	.06-.13	650-850
Culligan H-82C	5 sq ft thin film membrane, 5 micron sediment filter, 8 oz granular carbon prefilter, 2 oz granular carbon postfilter.	10.4	>92	>99	>91	96	93	88	85	.07-.13	625-750
Enting Aquamate	2.5 sq ft thin film membrane, 4.2 sq ft 5 micron sediment filter, 12.5 oz granular carbon prefilter.	10.4	>92	99	>91	97	97	>89	89	.08-.24	489-529
ACTIVATED CARBON FILTER											
Water Equipment Technologies	32 oz solid block carbon filter.	2	87	98	>91	NSC[3]	NSC	NSC	NSC	Average .06	198

1 Cost/gal is based on replacement filter costs. Replacement of the membrane in RO units would be substantial and is not included.
2 Carbon filter capacity is limited by filter life.
3 NSC = No Significant Change

NOTE: It should be noted that all of the above units are faucet bypass, having an individual tap for drinking water. Average drinking water use in the home is 3-5 gal/day. Furthermore, it is recommended that the RO units should be installed with a storage tank to facilitate higher-than-average demand conditions.

F. EFFICIENCY OF POINT-OF-USE TREATMENT DEVICES, (Regunathan, P., et al.)

Performances of two devices for point-of-use treatment are reported. One device was a combination of a granular-activated carbon bed and a precoat filter; the other was a combination of a reverse osmosis (RO) unit, a prefilter, and two granular carbon absorption units. These devices were studied to determine their abilities to remove various organic, inorganic, microbiological, and particulate contaminants from potable water.

Precoat filters have a finely powdered filter medium, usually activated carbon applied to the influent side of the filter. This layer is usually a few millimeters thick and can remove particulates 1 µm or smaller in diameter. A significant advantage to these filters is that they do not readily channel and dump the removed materials or rupture when the pressure drop gets too high.

Reverse osmosis units are excellent at removing particulates, suspended solids, inorganics, and larger organic molecules. RO alone is ineffective at removing trihalomethanes and other organics. Granular activated carbon units operate in the reverse; excellent at removing THMs and organics but almost completely ineffective at removing inorganics or particulates.

The results from this study indicate that, if properly designed and used, point-of-use treatment devices can be effective supplements to centralized treatment systems. A wide variety of contaminants can be removed with these units. The removal percentages are given in Tables 10 and 11.

Contrary to other reports, the data collected did not support the idea of increased bacterial contamination from the use of home water treatment devices. The precoat filters and similar fine-particle filter systems may have been principally responsible for the lower microbial growth. It was determined that the level of indigenous bacteria will rise during extended periods of nonuse , whether or not a filter is present. Samples from unit effluents were found to have lower levels of artificially induced coliform bacteria. Those coliforms that penetrated the filtration barriers did not colonize effluent surfaces and grow to larger numbers.

TABLE 10. REMOVAL OF CONTAMINANTS IN DRINKING WATER BY RO-CARBON AND GRANULAR-PRECOAT DEVICES

Contaminant	Maximum Contaminant Level*	RO-Carbon Device**		Granular-Precoat Device	
		Influent Concentration	Percent Removal	Influent Concentration	Percent Removal
Total trihalomethanes-µg/L	100	770	90-100	150-675	85-100
Chloroform-µg/L		400	90-100	200-470	85-100
Chlorodibromomethane-µg/L		130	95-100		NT[1]
Bromodichloromethane-µg/L		90	95-100		NT
Bromoform-µg/L		140	95-100		NT
Carbon Tetrachloride-µg/L		20	95-100	15-44	90-100
Nonpurgeable total organic halogen-µg/L			NT	100	75-100
Nonpurgeable total organic carbon-mg/L			NT	2.5	25-75
Endrin-µg/L	0.2	2	99-100		NT
Methoxychlor-µg/L	100	1000	99-100		NT
Lindane-µg/L	4	40	99-100		NT
Polychlorinated biphenyls-µg/L		100	99-100		NT
Total organic carbon-mg/L		10-12	99-100		NT
Total dissolved solids-mg/L	500	1275	88		NA[2]
Nitrate-mg/L	45	100	40		NA
Fluoride-mg/L	1.4-2.4	100	85		NA
Chloride-mg/L	250	470	87		NA
Sulfate-mg/L	250	215	98		NA
Sodium-mg/L		270	82		NA
Chromium III-µg/L	50	3400	88		NA
Cadmium-µg/L	10	900	76		NA
Barium-mg/L	1	10.6	71		NA
Lead-µg/L	50	2100	72		NA
Silver-µg/L	50	600	34		NA
Turbidity-tu[3]	5		NT	3-5	95-100
Asbestos-MFL[4]		>200	99	120	99

* Recommended or proposed limit

** Operated at 25°C and 340 kPa (50 psi)

1 Not tested

2 Not applicable

3 AC fine test dust, AC Spark Plug Div., General Motors Corp., Flint, Mich.

4 Million fibers per litre

TABLE 11. HEAVY METAL REMOVAL BY RO MODULES

Metal	Influent Concentration mg/L	Percent Rejection
Chromium III	0.5	85
	3.4	88
Cadmium	0.9	76
Barium	10.6	71
Lead	0.5	55
	2.1	72
Silver	0.6	34
	2.8	20

*Pressure = 310 ± 5 kPa (45 ± 0.5 psi): temperature = 23.5°C-29.5°C

G. TESTING OF HOME USE CARBON FILTERS,
(Taylor, Raymond H., et al.)

The rate at which consumers are buying point-of-use carbon filtration devices has been steadily rising over the past several years. There has been little scientific data to validate the claims of water quality improvement advertised by the manufacturers or to identify the potential problems associated with bacterial accumulation. The few papers published have been contradictory. In response to the need for useable data, the authors tested four carbon filters under controlled laboratory conditions, simulating home use conditions.

Samples were analyzed for bacteriological counts, free residual chlorine, and total organic carbon. Standard plate counts (SPC) in the effluent were always higher than in the influent water, although the range was not as great as has been previously reported. The influent SPC averaged less than 10/mL, while the effluent exceeded 100/mL. SPCs on the afternoon samples, due to flushing, were considerably lower.

From this study, implications are that bacterial problems may be compounded by the use of carbon filters and result in an increased health hazard. Regardless of the health significance of high SPCs, excessive bacterial counts may exist in the effluents. The extent to which this bacterial growth occurs cannot be predicted accurately because of a variety of factors, including temperature, surface area of the carbon, volume and velocity flow, time of sampling, bacterial population in the effluent, and the chlorine removal efficiency of the filter. Any

point-of-use evaluation must consider each of these factors in establishing testing protocol.

H. BACTERIAL COLONIZATION OF POINT-OF-USE WATER TREATMENT DEVICES, (Geldreich, Edwin E., et al.)

The results of the study presented in this paper firmly establishes that the carbon filters in home water treatment devices can be colonized by bacteria. The bacterial count was found to vary between units of different design, between units of the same design, and between water samples from the same filter unit collected at different times of the day. Major considerations were the length of time the filter had been in use, design of the cartridge, temperature of the water, and species of the microorganism. The presence of residual chlorine greatly reduced and/or prohibited the colonization. It is when these filters are used with the tap water of marginal bacteriological quality that the health risk becomes more pronounced.

The degree of health risk from drinking water filtered with a home unit has yet to be quantified. In fact, the issue is hotly debated, with the two sides distinctly opposed in their views. The primary consideration is that these filters provide an excellent breeding ground supplying organic nutrients to support bacterial growth; thus, there is the potential for the bacteria to achieve a density which would make the filtered water more unsafe than nonfiltered water.

If the consumer decides to use point-of-use treatment devices, there are several important precautions which will limit the exposure to high levels of bacteria. The units should only

be used with chlorinated tap water, thus the existing level of bacteria is low. Change filters on a regular basis; each unit ideally would have an indicator built-in to signal replacement. Flush each unit for at least 30 seconds after periods of stagnation, i.e., 8-10 hours. Insulate filters to keep water temperature low, especially if the unit is installed near dishwashers. The lower temperature will aid in reducing bacterial growth.

I. PERFORMANCE TEST OF CONTINENTAL FILTER MODEL 2036 FOR REMOVAL OF CHLOROFORM, TRICHLOROETHYLENE, AND ETHYLENE DIBROMIDE FROM DRINKING WATER, (Lynch, Steven C.)

Two filter units were evaluated on their ability to remove selected organic chemicals, chloroform ($CHCL_3$), trichloroethylene (TCE), and ethylene dibromide (DB). New Orleans tap water spiked with 304 ppb $ChCl_3$, 61.8 ppb TCE, and 22.9 ppb EDB, was used as the challenge water. The filters had a lifetime filtering capacity of 750 gallons. Each contained from 3800 to 4200 grams of activated carbon of the Westvaco type.

The cycling schedule consisted of one 10.5 minute cycle each hour for 19 hours, and a 5-hour dormancy. Influent and effluent samples for each filter were analyzed for the contaminants using gas chromatograph with an electron capture detector. The contaminant concentration was determined using hexane extraction.

The units were tested beyond rated capacities. Approximately 2300 gallons of water were filtered. The second unit was stressed to 4600 gallons before significant chloroform breakthrough was noted. The range of contaminant reduction was from 88 to greater than 99 percent. The complete data set appears in Tables 12 and 13.

TABLE 13. ORGANIC CHEMICAL REDUCTION, CONTINENTAL MODEL 2036, UNIT 2

Date	Cumulative Challenge (gal/liter)	Challenge Water (ppb)			Filtered Water (ppb)			Contaminant Reduction (percent)		
		$CHCl_3$	TCE	EDB	$CHCl_3$	TCE	EDB	$CHCl_3$	TCE	EDB
11/7/84	3/11.4	321	73.3	25.3	ND	ND	ND	>99	>97	>94
11/8/84	199/753	377	72.2	24.4	<4	ND	ND	>99	>97	>93
11/9/84	399/1510	379	78.0	27.5	ND	ND	ND	>99	>97	>95
11/12/84	622/2354	391	72.3	26.0	6.0	ND	ND	>99	>97	>94
11/13/84	929/3516	415	75.6	28.6	ND	ND	ND	>99	>97	>95
11/14/84	1457/5515	124	33.6	20.8	<4	ND	ND	>97	>94	>93
11/15/84	1973/7468	228	51.2	32.8	5.0	ND	ND	>98	>96	>96
11/16/84	2368/8963	305	53.9	34.6	4.5	ND	ND	>98	>96	>96
11/17/84	2985/11298	369	41.4	26.5	7.8	ND	ND	>98	>95	>94
11/19/84	3613/13675	515	39.9	29.6	12.5	ND	ND	>98	>95	>95
11/20/84	4116/15579	200	42.3	29.6	26.8	ND	ND	87	>95	>95
11/21/84	4640/17562	220	38.3	23.2	36.4	ND	ND	83	>95	>95

ND - Not Detected (Detection limits are: $CHCL_3$ = 4 ppb/; TCE = 2 ppb; EDB = 1.5 ppb)
\> - greater than
< - less than

TABLE 12. ORGANIC CHEMICAL REDUCTION, CONTINENTAL MODEL 2036, UNIT 1

Date	Cumulative Challenge (gal/liter)	Challenge Water (ppb)			Filtered Water (ppb)			Contaminant Reduction (percent)		
		$CHCl_3$	TCE	EDB	$CHCl_3$	TCE	EDB	$CHCl_3$	TCE	EDB
10/23/84	6/22.7	149	42.3	12.6	<4	ND	ND	>97	>95	>88
10/24/84	207/783	276	61.9	24.4	<4	ND	ND	>99	>97	>94
10/25/84	423/1601	277	61.2	25.7	ND	ND	ND	>99	>97	>94
10/26/84	637/2411	304	57.7	22.4	ND	ND	ND	>99	>97	>94
10/29/84	853/3229	341	58.9	23.0	ND	ND	ND	>99	>97	>94
10/30/84	1091/4133	327	57.3	21.7	ND	<2	ND	>99	>97	>93
10/31/84	1273/4818	351	57.9	24.5	ND	ND	ND	>99	>97	>94
11/1/84	1478/5594	362	53.3	29.9	ND	ND	ND	>99	>96	>95
11/2/84	1716/6495	253	66.0	19.1	ND	ND	ND	>98	>97	>93
11/5/84	1878/7108	257	70.4	21.5	ND	ND	ND	>98	>97	>93
11/6/84	2066/7820	348	73.9	26.9	<4	ND	ND	>99	>97	>94
11/7/84	2269/8588	290	62.1	22.7	<4	ND	ND	>99	>97	>94

ND - Not Detected (Detection limits are: $CHCL_3$ = 4 ppb/; TCE = 2 ppb; EDB = 1.5 ppb)
\> - greater than
< - less than

J. LABORATORY TREATABILITY STUDY FOR SELECTED ORGANIC PRIORITY POLLUTANTS IN AN INDUSTRIAL WASTEWATER, (Smith, J.K.)

This report evaluated two types of activated carbon for their performance in removing selected priority pollutants. The results of this report indicate performance efficiency will vary between carbon types; furthermore, the efficiency is pH-related. At lower contaminant concentrations, the ratio of the pollutant sorbed per unit of carbon increases as the pH decreases. This trend was not observed at higher concentration levels.

The performance data for HDC Carbon and S-51 Carbon are presented in Table 14. Of particular interest are the data for Benzene. The initial concentration in the influent (untreated effluent) was 36.3 ppm; an addition of 0.1 grams of HDC Carbon lowered the residual concentration to 25.8 ppm. A dosage of 10.5 grams reduced the concentration to 8 ppb. In comparison, 10.5 grams of S-51 Carbon reduced the pollutant to 1 ppb. All carbon dosages are expressed as grams per 100 mL of solution (untreated effluent). Only data for pH range 7 are given, since the pH of drinking water is normally neutral.

TABLE 14. EQUILIBRIUM CONCENTRATION OF CONTAMINANTS IN ACTIVATED CARBON STUDIES AT pH7.

Constituent (ppm)	Untreated Effluent	ICI (HDC) Carbon[1]					ICI (S-51) Carbon[1]				
		0.1	0.5	1.0	5.0	10.5	0.1	0.5	1.0	5.0	10.5
TOC[2]	1418	1223	800	454	30.2	19.1	1130	856	378	35.8	17.4
Chlorobenzene	8.8	3.28	2.64	0.186	0.002	--	2.68	0.323	0.042	0.0004	--
Dichlorobenzene	36	0.900	0.032	0.003	--	--	0.238	0.041	0.003	--	--
Nitrobenzene	166	72.4	7.70	0.989	0.009	0.0009	35.3	7.95	1.08	0.006	0.0005
Phenol	30.8	28.2	17.8	3.34	0.038	0.0012	26.7	16.9	5.65	0.020	0.0010
Dinitrotoluene	7.9	1.21	1.13	0.014	0.011	0.0006	0.829	0.856	0.007	0.002	0.0007
1,2,-dichloropropane	3.5	2.30	0.99	0.390	0.001	0.0005	2.50	1.00	0.24	0.003	--
Benzene	36.3	25.8	17.6	7.96	0.102	0.008	26.9	10.9	7.14	0.055	0.001

1 Dosages in grams per 100 ml of solution.
2 Total Organic Carbon.

K. EFFECTIVENESS OF VARIOUS ADSORBENTS IN REMOVING ORGANIC COMPOUNDS FROM WATER-REMOVING PURGEABLE HALOGENATED ORGANICS, (Wood, Paul R. and DeMarco, Jack)

This study was conducted to evaluate the effectiveness of granular-activated carbon (GAC), and two synthetic resins in removing halogenated organics from drinking water processed by the John E. Preston Water Treatment Plant in Miami, Fl. The plant utilizes a combination of lime-softening, breakpoint chlorination, and sand filtration during the treatment process. As the water exits the plant, the free chlorine level is adjusted to 3 ppm.

Glass columns, 1 inch in diameter were packed with GAC to bed depths of 2.5, 5, 7.5, and 10 feet. Each column contained 275, 550, 825, and 1100 grams of carbon with empty bed contact times of 6.2, 12.4, 18.6, and 24.8 minutes, respectively. The flow rate was regulated to 1 gallon/hour. Filtrasorb 400, manufactured by the Calgon Corporation, was the type of carbon used.

Contaminant influent concentrations to the four columns and effluent levels from each were determined twice weekly. A summarization of the breakthrough data for Column 4 appears in Table 15. Table 16 lists the influent and effluent concentrations of vinyl chloride. The breakthrough point was defined as the point at which the chemical concentration in the effluent exceeded 2 µg/L. Column saturation occurred when the effluent equaled and/or exceeded the influent concentration.

TABLE 15. GAC COLUMN BREAKTHROUGH DATA FOR SPECIFIC HALOGENATED ORGANICS

Chemical Name	Average Influent (µg/L)	Column[1] Breakthrough (days)	Column[2] Saturation (days)
Bromoform	2.5	N[3]	N
Vinyl Chloride	6.2	35	87
Chloroform	67.3	72	98
Cis-1,2-Dichloroethane	18.3	N	N
Bromodichloromethane	47	105	>139
1,1,1-Trichloroethane 1,2-Dichloroethane Carbon Tetrachloride	7.7	N	N
Chlorodibromomethane	33.6	N	N

1 Breakthrough defined as the point at which effluent concentration <2 µg/L.

2 Point at which effluent is greater than or equal to influent concentration.

3 No breakthrough measured. Effluent concentration < 2 µg/L.

TABLE 16. GAC REMOVAL DATA FOR VINYL CHLORIDE.

Date	Day[2]	Influent (µg/L)	Effluent[1] (µg/L) C 1	C 2	C 3	C 4
11/01/77	0	ND[3]	ND	ND	ND	ND
4	3	ND	ND	ND	ND	ND
8	7	11.1	3.2*	ND	.13	.06
11	10	8.2	8.2	ND	ND	ND
15	14	7.7	8.7	2.4*	.17	ND
18	17	ND	19.0	6.2	2.4*	ND
22	21	9.0	ND	3.5	.17	ND
25	24	12.6	5.3	9.2	ND	ND
29	28	10.2	5.2	ND	ND	ND
12/02/77	31	9.3	ND	ND	ND	ND
6	35	3.2	ND	ND	ND	ND
9	38	10.3	3.8	9.5	1.80	2.8*
13	42	5.4	1.70	3.7	5.4	2.8
16	45	2.4	1.60	2.8	8.0	5.2
20	49	6.8	1.80	1.80	3.4	3.8
23	52	8.9	4.1	2.7	1.80	5.7
27	56	9.3	2.5	2.7	3.1	4.2
30	59	4.5	6.9	6.4	5.7	3.7
1/03/78	63	11.2	4.4	3.5	2.2	3.8
6	66	16.8	4.0	2.7	4.6	2.7

1 Column 1, 275g carbon; column 2, 550g carbon; column 3, 825g carbon; column 4, 1100g carbon.

2 Test Duration 122 Days.

3 Not detected.

* Column breakthrough.

TABLE 16. GAC REMOVAL DATA FOR VINYL CHLORIDE.(CONCLUDED)

Date	Day[2]	Influent (µg/L)	Effluent[1] (µg/L) C 1	C 2	C 3	C 4
10	70	3.2	2.5	2.9	3.7	2.2
13	73	.52	7.9	5.0	1.50	6.5
17	77	14.9	6.8	1.4	8.6	2.7
20	80	9.0	10.1	7.2	8.4	2.4
24	84	7.2	5.2	4.3	2.3	4.5
27	87	4.4	7.0	5.8	6.9	13.4
31	91	1.9	2.6	3.2	2.0	6.6
2/03/78	94	11.3	3.5	1.60	1.20	1.20
7	98	8.8	.56	1.40	4.1	2.6
10	101	16.5	4.7	3.7	3.3	1.60
14	105	4.9	4.4	1.30	4.5	3.6
17	108	8.1	12.3	2.4	2.0	2.2
21	112	34.7	-	-	-	-
24	115	6.4	2.3	4.5	1.60	.84
28	119	17.9	7.0	.94	8.1	2.3
3/01/78	122	7.5	10.2	7.2	3.8	9.5

SECTION III

SUMMARY AND CONCLUSIONS

A. SUMMARY

The articles summarized in section two represent the work performed on home water units to the present. Although the number of scientific studies is low, enough data exist to support activated carbon as a viable means of removing organic contaminants. The data from the Amway Corporation are by far the most comprehensive. When the Amway data are compared to other studies, the removal percentages for identical chemicals are very similar. For that reason, the benzene and ethylbenzene data from Amway are considered to be a reliable indication of the expected performance for an activated carbon unit although there are no independent corroborating data. Therefore, of the compounds commonly found at Air Force hazardous waste sites, vinyl chloride is the only compound in need of supporting data. The absence of data for vinyl chloride is most likely due to the difficulties encountered in preparing standards and running the analyses. Vinyl chloride has a high volatility and polymerizes easily, requiring special handling within the laboratory.

A study on granular activated carbons was evaluated to obtain data for vinyl chloride. Data taken from the Wood and DeMarco study indicate that activated carbon will remove vinyl chloride from drinking water. However, vinyl chloride saturates the carbon quicker than other halogenated organics. A comparison of the breakthrough and saturation times for the chemicals listed

in Table 15 indicates that vinyl chloride is the first contaminant to appear in the effluent with concentrations exceeding 2 µg/l. In areas where the drinking water contains vinyl chloride, the carbon filter should be replaced more frequently.

B. CONCLUSIONS

The performance of a home water treatment system using activated carbon combines the system design, type and amount of carbon, and the amount of time the water is in contact with the carbon. An efficient system will achieve high removal rates, averaging 90 percent for trihalomethanes and 95 percent for other halogenated organics, over the filter's lifetime capacity.

In addition to its average performance, the removal percentage range over filter life is important, i.e., beginning and ending performance figures. The rated gallonage for each filter should be examined and redefined, if necessary, to achieve high-performance removal rates over filter life. Generally, removal percentages will be higher as the filter is first put on line and will drop as the rated capacity is reached. The degree of reduction will separate a good filter from a poor performer. Obviously, a rupture in the filter will cause a sudden drop in performance. Carbon loading is a more reasonable explanation. As the active sites of the carbon become filled, the ratio of the number of available sites to the contaminant concentration decreases, resulting in a decrease in filter performance.

With the exception of the Culligan unit, the recommended filters (Table 2) exhibited excellent performance over the filter

life. The Culligan unit had an extended rated gallonage of 4,000 which attributed to its slightly decreased performance. Performance data at 2,000 gallons were comparable to the other units, signifying the need to examine closely the rated gallonage. More complete data and charts, detailing lifetime performance, are given in the GSRI, Phase II Report to the EPA. This report can be ordered through National Technical Information Service (NTIS).

Extended lifetime capacities prompt the need for a maximum filter replacement time. A replacement every 6 months would be a practical yet acceptable value. Some manufacturers recommend once a year. One of the inherent dangers with a longer replacement time is the potential for increasing bacterial growth and/or bacterial or chemical unloading. Inevitably these filters will degrade with time and use. The establishment of a maximum time limit, not to exceed rated gallonage, would add an additional margin of safety to their use.

Please note that the model numbers for the carbon filters listed in this report are current as of the study date. The manufacturer may have switched to a different model and the listed filter may no longer be available.

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